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Picking up the pennies in front of the bulldozer: The profitability of gilt based trading strategies

by

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Abstract

We develop a simple cointegrated pairs trading strategy, including automatic risk control and adjustment for short-selling costs. We applied the strategy to the previously untested and highly liquid market for gilt futures. Profitability is exploited through the mean reversion in the relationship between long and medium gilt futures, and between medium and short gilt futures. Results show the potential for arbitrage profits exists, even using a relatively unsophisticated model, particularly between long and medium gilt futures.

Keywords: arbitrage trading; fixed income market; market efficiency; UK gilt futures.

1. Introduction

Cointegrated pairs trading has been widely used by hedge funds and proprietary traders since Nunzio Tartaglia first introduced the concept at Morgan Stanley in 1987. Due to the traditionally secretive nature of such practitioners, however, the corresponding literature is comparatively light.

Gatev et al. (1999, 2006) considered the US equities market and were able to demonstrate that by taking this “disarmingly simple” approach, even after trading costs, the strategy was profitable. Most other studies also focus solely on US equity markets (Elliott et al., 2005; Do and Faff, 2010, 2012; Galenko et al., 2012; Vidyamurthy, 2004). More recent work, however, has considered pairs trading in regional and developing stock markets (e.g. Bogomolov, 2011; Panyagometh, 2013; Caldeira and Moura, 2013).

Studies that venture into bond markets are rare. Krishnamurthy (2002) considers the trade in old/new 30 year US bonds¹. Nath (2003) considers a broad spectrum of US government debt and provides a convincing case for trading government securities over equities which we summarise in Table 1.

	Equities	Government Bonds
Liquidity	Varies	High
Trading costs (bid-ask spread & broker commission)	Higher	Lower
Cointegration	Low	High
'Training' period	Long	Short
Risk & return	Higher	Lower
Leverage costs	High	Low
Shorting: ease & cost	Lower & higher	Higher & lower
Shorting: social acceptance	Can be low	Less affected
Efficient price	Hard to determine	Tightly bounded

Table 1: Pairs Trading in Equities and Government Bonds

Our paper contributes to this sparse literature by developing a bespoke pairs trading strategy based on UK government bond futures of different maturities. Trading gilt futures is more appealing than trading bonds due to their standardised nature on an authorised exchange which ensures there is no counterparty risk to entering and exiting positions.

¹The trading strategy made famous by Long Term Capital Management (see Lowenstein, 2000).

A key issue when implementing a pairs trading strategy is identifying a suitably cointegrated pair. Government securities, and the futures based on them, are by nature strongly cointegrated (see, e.g. Bradley and Lumpkin, 1992; Dueker and Startz, 1998; Campbell and Shiller, 1987; Haug, 1991). We therefore sidestep one of the main practical difficulties through having the pairs cointegration already established.

Krishnamurthy (2002) found that the gains due to trading US bonds were marginal once the cost of financing in the repo markets was taken into account. In contrast Nath (2003) identified arbitrage profits despite these costs. This study provides new evidence that arbitrage profits exist in UK bond futures after controlling for the costs of financing.

Section 2 describes the data used in the study, its source and some inherent issues. Section 3 discusses the detail of the methods employed, followed by the main results in section 4. Section 5 concludes.

2. Data

Gilt futures, traded on ICE Futures Europe, exist for the months of March, June, September and December. Gilt futures may be 'long', 'medium' or 'short'. Each contract is for £100,000 nominal value (an example specification for a long gilt contract is shown in table 2 below) and prices are quoted per £100 nominal.

Unit of trading	UK gilt bond having a face value of £100,000, a notional coupon of 4% and a notional maturity of 10 years (changed from contract value of £50,000 from the September 1998 contract)
Deliverable grades	UK gilts with a maturity ranging from 8¾ to 13 years from the first day of the delivery month (changed from 10–15 years from the December 1998 contract)
Delivery months	March, June, September, December
Delivery date	Any business day during the delivery month
Quotation	Per cent of par expressed as points and hundredths of a point, for example 114.56 (changed from ticks and 1/32nds of a point, as in 117–17 meaning 114 17/32 or 114.53125, from the June 1998 contract)
Minimum price movement	0.01 of one point (one tick)
Tick value	£10
Trading hours	08:00–18:00 hours All trading conducted electronically on LIFFE CONNECT™ platform

Table 2: LIFFE long gilt future contract specification. Source: LIFFE.

For the most part, data for this study was sourced from Quandl². The data obtained (e.g. files GZ2015, HZ2015 and RZ2015 – corresponding to short, medium and long December 2015 price series) were then compiled to produce a single month / year file for processing.

The range of available data for long gilt futures was considerably greater than for medium and short gilt futures. The need for comparison therefore constrained the available datasets to March, June, September and December maturities for 2014 and 2015, together with December for 2013. The period covered by each series varied considerably, so a common

² <https://www.quandl.com/collections/futures/liffe>

duration of 75 days of prices was chosen across the sets. This maturity choice also ensures a substantial amount of liquidity in trading.

We used daily settle values to model the futures prices. Ideally the median of the bid-ask spread together with many intraday values (see, e.g. Bowen et al. 2010; Miao, 2014) would have been preferred, but the bid-ask spread tends to be tight, and this analysis is primarily ‘proof of concept’ so in this context our approach is considered acceptable. (We also assume transaction costs are subsumed into the settle price.)

The 3 month GBP LIBOR rate was used as a proxy for the short selling repo cost (paralleling Nath, 2003, who chose the Fed Funds Rate for his study of US government bonds). This ignores the possibility of any ‘on special’ rates that may be available (see Choudhry, 2002)

3. Methodology

There are three main approaches to implementing pairs trading strategies:

1. distance based methods (e.g. Gatev et al., 1999; Nath, 2003); cointegration (Vidyamurthy, 2004),
2. the stochastic spread method (Elliott et al. 2005),
3. the stochastic residual spread (Do et al., 2006).

Each of the approaches involves a training period when the model is parameterised, followed by a trading period when it is applied.

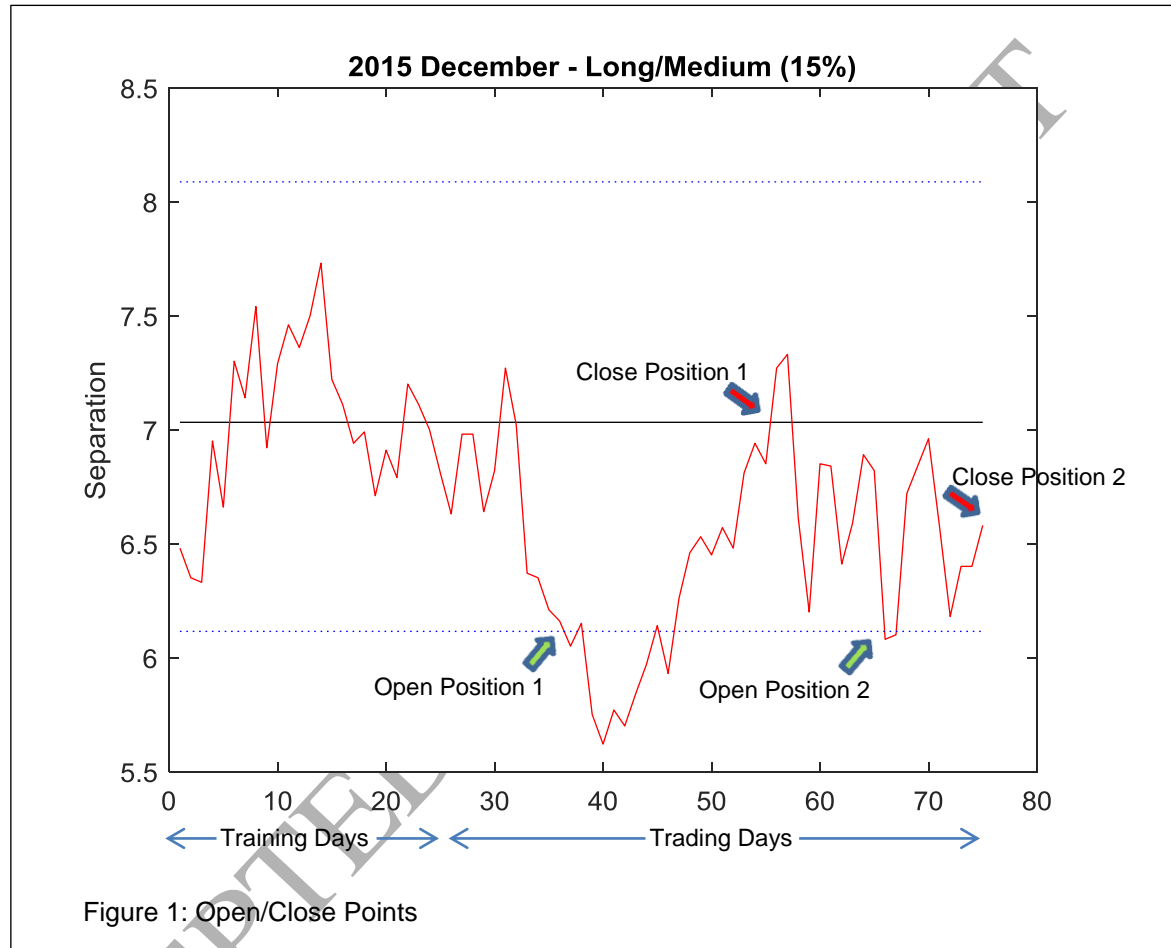
We developed our model using MATLAB code (see Appendix A) and tested it against calculations performed manually on a subset of the data. Our approach is essentially a simple distance method, outlined as:

1. Calculate the mean separation (spread) between the two elements of the pair over the training period.
2. Open the trade (using normalised prices) when the spread crosses a trigger level – a percentage of the mean separation during the training period.
3. Close the position when one of the following occurs:
 - the spread reverts to the mean
 - the last trading day is reached
 - the spread widens to a ‘stop loss’ level
4. Adjust the profit / loss to include repo cost

The first reason for closure results in profit, the second in either profit or loss, and the third results in a loss. The third reason models the risk a trader faces from the pair separating to such an extent that margin calls may be made, or reflecting their preference to close the position rather than risk what may be a permanent change in the spread.

Figure 1 (below) shows the strategy outworked in the case of the Long-Medium pair for futures expiring in December 2015, with a training period of 25 days, and a trading period of 50 days. The horizontal black line at 7.032 shows the mean separation calculated during the training period, and the blue dotted lines reflect the trigger levels ($\pm 15\%$ of the mean). The

green Open Position 1 arrow shows the point at which the separation series crosses the trigger line causing the position to be opened, i.e. the Long is bought and an equivalent amount of the Medium is sold short. At the red Close Position 1 arrow, the series reaches the mean again, so the position is closed and profit made. The position is opened again at Open Position 2 and closed again at the end of the trading period.



It can be seen from examining the data that the prices in the different future types maintain a consistent relationship of Long > Medium > Short across all the datasets. It can also be seen for the prices on any given day that:

$$(Long - Medium) + (Medium - Short) = (Long - Short)$$

though both (Long - Medium) & (Medium - Short) fluctuate. The pairs formed were therefore Long & Medium and Medium & Short for each of the datasets tested.

The code was developed to allow the training days / trading days balance to be adjusted. A range of different values was trialled, and a good result was obtained with a close-to-even

split of 35 days training and 40 days trading, in keeping with the sort of split used by Nath (2003).

Three different trigger levels were trialled (10%, 15% & 20%) and the differing results recorded.

A range of values for the Stop Loss parameter were also trialled. Its value was found to be significant, for example setting to a number that could never be reached actually resulted in aggregate loss in some cases. A reasonable level was found to be 30% beyond the trigger level.

Although normalisation was applied to the trading calculations, in some ways this is slightly artificial given that the instruments trade in multiples of £100k – though, in theory, a sufficiently large position could be constructed to create a perfect hedge.

4. Results

It would be possible to generate an almost infinite set of results based on varying the trigger level, stop-loss level, and training/trading periods. The purpose of the study, however, is not so much to find the optimum trading strategy for long, medium and short gilt futures, but rather to verify whether or not the strategy is plausible at all. On that basis, the findings presented are used as illustrative examples.

The results in tables 4, 5 and 6 (below) were each generated using a training period of 35 days followed by a trading period of 40 days, with a stop-loss level of 30% beyond the trigger levels. Even though the overall position should be self-financing, the percentage gain/loss was calculated based on the gain per amount invested in the normalised long position.

In each case, the Long-Medium pair was seen to generate positive returns. As expected, the 10% trigger level generated the most open positions, 14 (of which 12 were closed before the end of trading). It also generated the highest aggregate percentage gain (3.51%) over the 9 quarters in the test sample. With the 15% and 20% trigger levels all of the opened positions were closed before the end of trading. Across the three tables more than half of all closures were made as stop-loss closures, though this was clearly not particularly detrimental to the overall profit.

In the Medium-Short pair a loss was seen at each trigger level. The 10% level again saw the greatest number of open positions, 6 (of which only 1 was closed during trading), although this time it generated the highest loss (-0.8926%). The overall, though comparatively small, loss across the three trigger levels is seen to result from opening positions that fail to close before the end of trading. It is also notable that as expected there is a reduction in the number of opened positions as the trigger level increases.

With a different set of parameters, however, the Medium-Short pair can also be seen to make a positive return. For example, a trigger level of 5% and stop-loss of 10% results in a return of 0.6275% from 13 opened positions, 9 of which closed within the trading period and 4 of these from stop-loss closures.

These results represent a position somewhere between Nath (2003) and Krishnamurthy (2002) – i.e. gains can be made, even after the cost of short-selling, but the margins are slim.

10% Trigger Level

ID	DataSet	Long-Medium			Medium-Short		
		% Gain	# Positions Open/Close	# Stops	% Gain	# Positions Open/Close	# Stops
1	2015 December	1.8749	3 / 2	0	0	0	0
2	2015 September	-0.9125	1 / 1	1	-0.3676	1 / 0	0
3	2015 June	0.7842	1 / 1	1	-0.1840	1 / 0	0
4	2015 March	3.0581	3 / 2	0	0.7317	1 / 1	0
5	2014 December	-0.7223	1 / 1	1	-0.8747	1 / 0	0
6	2014 September	-0.5777	1 / 1	1	0.0432	1 / 0	0
7	2014 June	0.0094	4 / 4	2	0	0	0
8	2014 March	0	0	0	0	0	0
9	2013 December	0	0	0	-0.2412	1 / 0	0
		3.5141	14 / 12	6	-0.8926	6 / 1	0

Table 4: Results: 10% trigger level

15% Trigger level

ID	DataSet	Long-Medium			Medium-Short		
		% Gain	# Positions Open/Close	# Stops	% Gain	# Positions Open/Close	# Stops
1	2015 December	1.2542	1 / 1	0	0	0	0
2	2015 September	-1.1138	1 / 1	1	-0.1059	1 / 0	0
3	2015 June	0.8996	1 / 1	1	0	0	0
4	2015 March	3.0690	2 / 2	0	0	0	0
5	2014 December	-1.1794	1 / 1	1	-0.6041	1 / 0	0
6	2014 September	-0.5777	1 / 1	1	0.2029	1 / 0	0
7	2014 June	-0.5694	4 / 4	2	0	0	0
8	2014 March	0	0	0	0	0	0
9	2013 December	0	0	0	0	1 / 0	0
		1.7825	11 / 11	6	-0.5071	4 / 0	0

Table 5: Results: 15% trigger level

20% Trigger level

ID	DataSet	Long-Medium			Medium-Short		
		% Gain	# Positions Open/Close	# Stops	% Gain	# Positions Open/Close	# Stops
1	2015 December	1.2542	1 / 1	0	0	0	0
2	2015 September	-1.2454	1 / 1	1	0	0	0
3	2015 June	1.4134	1 / 1	1	0	0	0
4	2015 March	3.4719	2 / 2	0	0	0	0
5	2014 December	-1.1163	1 / 1	1	-0.2386	1 / 0	0
6	2014 September	-1.7244	2 / 2	2	0	0	0
7	2014 June	0.0018	3 / 3	2	0	0	0
8	2014 March	0	0	0	0	0	0
9	2013 December	0	0	0	0	0	0
		2.0552	11 / 11	7	-0.2386	1 / 0	0

Table 6: Results: 20% trigger level

5. Conclusions

The aim of this study was to explore arbitrage profits in the previously untested UK gilt futures market. Lowenstein (2000) quotes the warning given to LTCM over their old/new 30 year US government bond strategy, “you’re picking up nickels in front of a bull-dozer”. In many ways, this study sought to answer the question “can such nickels still be found?”

The model we developed involved the important inclusion of a stop-loss risk adjustment and an attempt to model the cost of short-selling. Our findings suggest some level of profitability especially in strategies between Long-Medium gilt futures. Our paper adds to the important but sparse literature investigating arbitrage trading profits in the fixed income markets. While remaining uncertain about nickels, it would appear that UK pennies could be available.

An extension would be to explore the effects of quantitative easing on the strategy, and also the differential effects of interest rate changes on the futures spreads. While further tests of the strategy in the same context are clearly warranted, other avenues that could also be pursued are the US government bond futures market, and cross pairs between UK and US bond futures – assuming suitable cointegration could be established.

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Appendix A: Model Code

```

% Read set of data files to process
DF_ID = fopen('DataSet.txt','r');
DF = textscan(DF_ID,'%f %s %f %f');
fclose(DF_ID);

% Set parameters & arrays
fid_v      = DF{1};
Datafile_v = DF{2};
Trigger_v  = DF{3};
Repo_v     = DF{4};
n_dataset  = length(fid_v);
Training   = 35;
Trading    = 40;
Stoploss   = 0.30;

% Output array
out = zeros(n_dataset,12);

% Main routine
for j=1:n_dataset
    % Main processing loop

    % Loop parameters
    Fid      = fid_v(j);
    Datafile = char(Datafile_v(j));
    Trigger  = Trigger_v(j);
    Repo     = Repo_v(j);

    % Read data from each file in turn
    fileID = fopen(Datafile,'r');
    F = textscan(fileID,'%f %f %f');
    fclose(fileID);

    % Populate class properties (in reverse order, i.e. row 1 is now oldest)
    p_l = flipud(F{1}); % Long gilt prices
    p_m = flipud(F{2}); % Medium gilt prices
    p_s = flipud(F{3}); % Short gilt prices

    % Separations: Long-Medium & Medium-Short
    lm_sep = p_l - p_m;
    ms_sep = p_m - p_s;

    % Training - Mean separations & boundaries: Long-Medium & Medium-Short
    lm_mean = sum(lm_sep(1:Training))/Training;
    lm_plus = lm_mean * Trigger;
    lm_minus = lm_mean / Trigger;
    lm_pstop = lm_mean * (Trigger + Stoploss);

```



```

lm_mstop = lm_mean / (Trigger + Stoploss);
ms_mean = sum(ms_sep(1:Training))/Training;
ms_plus = ms_mean * Trigger;
ms_minus = ms_mean / Trigger;
ms_pstop = ms_mean * (Trigger + Stoploss);
ms_mstop = ms_mean / (Trigger + Stoploss);

```

```

% Process trading days

```

```

%
% Long - Medium
%
p_lopen = 0; p_mopen = 0; lm_open = 0; lm_close = 0; lm_stop_c = 0;
lm_ret = 0; lm_cumret = 0; lm_pcntg_ret = 0;

```

```

% Establish stop limits
if lm_sep(Training+1) <= lm_mstop
    mstop = 1;
else
    mstop = 0;
end
if lm_sep(Training+1) >= lm_pstop
    pstop = 1;
else
    pstop = 0;
end

```

```

for i = Training+1:Training+Trading

```

```

    if lm_open == lm_close; % No open positions

```

```

        if lm_sep(i) <= lm_minus && ~mstop
            % Boundary crossed below -> open position
            p_lopen = p_l(i);
            p_mopen = p_m(i);
            abv_bel = 0;
            lm_open = lm_open + 1;
        elseif lm_sep(i) >= lm_plus && ~pstop
            % Boundary crossed above -> open position
            p_lopen = p_l(i);
            p_mopen = p_m(i);
            abv_bel = 1;
            lm_open = lm_open + 1;
        end

```

```

        if mstop && lm_sep(i) > lm_minus % Back inside so reset
            mstop = 0;
        end

```

```

        if pstop && lm_sep(i) < lm_plus % Back inside so reset
            pstop = 0;
        end
    end

```

```

else % Positions are open

if abv_bel % Opened above

    if lm_sep(i) <= lm_mean % Reverted -> Close
        lm_ret = (p_m(i)-p_mopen) - (p_mopen/p_lopen)*(p_l(i)-p_lopen);
        lm_pcngtg_ret = lm_pcngtg_ret + (lm_ret * 100/p_mopen);
        lm_cumret = lm_cumret + lm_ret;
        lm_close = lm_close + 1;
    elseif lm_sep(i) >= lm_pstop % Stoploss reached -> Close
        lm_ret = (p_m(i)-p_mopen) - (p_mopen/p_lopen)*(p_l(i)-p_lopen);
        lm_pcngtg_ret = lm_pcngtg_ret + (lm_ret * 100/p_mopen);
        lm_cumret = lm_cumret + lm_ret;
        lm_close = lm_close + 1;
        pstop = 1;
        lm_stop_c = lm_stop_c + 1;
    end

else % Opened below

    if lm_sep(i) >= lm_mean % Reverted -> Close
        lm_ret = (p_l(i)-p_lopen) - (p_lopen/p_mopen)*(p_m(i)-p_mopen);
        lm_pcngtg_ret = lm_pcngtg_ret + (lm_ret * 100/p_lopen);
        lm_cumret = lm_cumret + lm_ret;
        lm_close = lm_close + 1;
    end
    if lm_sep(i) <= lm_mstop % Stoploss reached -> Close
        lm_ret = (p_m(i)-p_mopen) - (p_mopen/p_lopen)*(p_l(i)-p_lopen);
        lm_pcngtg_ret = lm_pcngtg_ret + (lm_ret * 100/p_mopen);
        lm_cumret = lm_cumret + lm_ret;
        lm_close = lm_close + 1;
        mstop = 1;
        lm_stop_c = lm_stop_c + 1;
    end
end
end
end
end

if lm_open ~= lm_close % Still open -> close at
maturity
    if abv_bel
        lm_ret = (p_m(i)-p_mopen) - (p_mopen/p_lopen)*(p_l(i)-p_lopen);
        lm_pcngtg_ret = lm_pcngtg_ret + (lm_ret * 100/p_mopen);
        lm_cumret = lm_cumret + lm_ret;
    else
        lm_ret = (p_l(i)-p_lopen) - (p_lopen/p_mopen)*(p_m(i)-p_mopen);
        lm_pcngtg_ret = lm_pcngtg_ret + (lm_ret * 100/p_lopen);
        lm_cumret = lm_cumret + lm_ret;
    end
end
end

```

% Medium - Short

```
ms_open = 0; ms_close = 0; p_lopen = 0; p_mopen = 0; ms_stop_c = 0;
ms_ret = 0; ms_cumret = 0; ms_pcntg_ret = 0;
```

```
if ms_sep(Training+1) <= ms_mstop
    mstop = 1;
```

```
else
    mstop = 0;
```

```
end
```

```
if ms_sep(Training+1) >= ms_pstop
    pstop = 1;
```

```
else
    pstop = 0;
```

```
end
```

```
for i = Training+1:Training+Trading
```

```
    if ms_open == ms_close; % No open positions
```

```
        if ms_sep(i) <= ms_minus && ~mstop
            % Boundary crossed below -> open position
```

```
            p_mopen = p_m(i);
```

```
            p_sopen = p_s(i);
```

```
            abv_bel = 0;
```

```
            ms_open = ms_open + 1;
```

```
        elseif ms_sep(i) >= ms_plus && ~pstop
            % Boundary crossed above -> open position
```

```
            p_mopen = p_m(i);
```

```
            p_sopen = p_s(i);
```

```
            abv_bel = 1;
```

```
            ms_open = ms_open + 1;
```

```
        end
```

```
        if mstop && ms_sep(i) > ms_minus % Back inside so reset
```

```
            mstop = 0;
```

```
        end
```

```
        if pstop && ms_sep(i) < ms_plus % Back inside so reset
```

```
            pstop = 0;
```

```
        end
```

```
    else % Positions are open
```

```
        if abv_bel % Opened above
```

```
            if ms_sep(i) <= ms_mean % Reverted -> Close
```

```
                ms_ret = (p_s(i)-p_sopen) - (p_sopen/p_mopen)*(p_m(i)-p_mopen);
```

```
                ms_pcntg_ret = ms_pcntg_ret + (ms_ret * 100/p_sopen);
```

```
                ms_cumret = ms_cumret + ms_ret;
```

```
                ms_close = ms_close + 1;
```

```
            elseif ms_sep(i) >= ms_pstop % Stoploss reached -> Close
```

```

ms_ret = (p_s(i)-p_sopen) - (p_sopen/p_mopen)*(p_m(i)-p_mopen);
ms_pcntg_ret = ms_pcntg_ret + (ms_ret * 100/p_sopen);
ms_cumret = ms_cumret + ms_ret;
ms_close = ms_close + 1;
pstop = 1;
ms_stop_c = ms_stop_c +1;
end

else % Opened below

if ms_sep(i) >= ms_mean % Reverted -> Close
ms_ret = (p_m(i)-p_mopen) - (p_mopen/p_sopen)*(p_s(i)-p_sopen);
ms_pcntg_ret = ms_pcntg_ret + (ms_ret * 100/p_mopen);
ms_cumret = ms_cumret + ms_ret;
ms_close = ms_close + 1;
end
if ms_sep(i) <= ms_mstop % Stoploss reached -> Close
ms_ret = (p_s(i)-p_sopen) - (p_sopen/p_mopen)*(p_m(i)-p_mopen);
ms_pcntg_ret = ms_pcntg_ret + (ms_ret * 100/p_sopen);
ms_cumret = ms_cumret + ms_ret;
ms_close = ms_close + 1;
mstop = 1;
ms_stop_c = ms_stop_c +1;
end
end
end
end

if ms_open ~= ms_close % Still open -> close at maturity
if abv_bel
ms_ret = (p_s(i)-p_sopen) - (p_sopen/p_mopen)*(p_m(i)-p_mopen);
ms_pcntg_ret = ms_pcntg_ret + (ms_ret * 100/p_sopen);
ms_cumret = ms_cumret + ms_ret;
else
ms_ret = (p_m(i)-p_mopen) - (p_mopen/p_sopen)*(p_s(i)-p_sopen);
ms_pcntg_ret = ms_pcntg_ret + (ms_ret * 100/p_mopen);
ms_cumret = ms_cumret + ms_ret;
end
end

outrow = [fid, Trigger, lm_cumret, lm_pcntg_ret-Repo, lm_open, lm_close,
lm_stop_c, ms_cumret, ms_pcntg_ret-Repo, ms_open, ms_close, ms_stop_c];
out(j,:) = outrow;

end % Main processing loop

```